NASA's Docket No.: LAR 16324-2 *PATENT*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re: application of: William Christopher Edwards, Terry L. Mack, and Edward A. Modlin
Application No.: 10/783,486 Group No.: 2636
Filed: 2/20/2004 Examiner: Lieu, Julie B.
For: Self-Activating System and Method for Alerting When an Object or a Person is Left Unattended

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AFFIDAVIT UNDER 37 C.F.R. § 1.131

William Christopher Edwards, Terry L. Mack and Edward A. Modlin, being duly sworn, depose and say that:

1. We are joint-inventors of claims 1-46 of the above-identified patent application.

2. William Christopher Edwards and Edward A. Modlin are employed by the National Aeronautics and Space Administration (NASA) at NASA Langley Research Center in Hampton, Virginia. Terry L. Mack is employed by Lockheed Engineering and Sciences Company and performs his duties at NASA Langley Research Center in Hampton, Virginia.

3. The sole reference cited in the prosecution of the instant patent application is the United States Patent Application Publication entitled "Object Proximity Monitoring and Alarm System," publication number US 2003/0062996 A1, publication date April 3, 2003, which claims the priority benefit of U.S. Provisional Patent Application Serial No. 60/325,852 filed September 28, 2001.

4. Before September 28, 2001, we completed the invention defined by claims 1-46 of the above-identified patent application in the United States of America.

5. In support of our assertion that we completed the invention defined by the instant claims in the United States of America before September 28, 2001, we submit herewith and attach hereto Exhibit A, which is a redacted photocopy of the Disclosure of Invention that we prepared and submitted before September 28, 2001, to the NASA Langley Research Center Patent Counsel Office located in Hampton, Virginia, and that was received therein before September 28, 2001. Exhibit A is a redacted photocopy because dates have been blocked off. All of the dates redacted in Exhibit A are before September 28, 2001. These redacted dates include the dates originally provided in Sections 14 and 17, which contained dates corresponding to each enumerated stage of development of the invention.

6. The Disclosure of Invention contains a written description of the subject matter claimed in the present invention and establishes our conception of the invention defined by claims 1-46 of the above-identified patent application in the United States of America before September 28, 2001.

7. In further support of our assertion that we completed the invention defined by claims 1-46 in the United States of America before September 28, 2001, we submit herewith and attach hereto Exhibit B, which is a photograph of a beta-version prototype of a self-activating system for alerting when an object or a person is left unattended in accordance with the invention defined by claims 1-46 of the above-identified patent application. The photograph of Exhibit B was taken before September 28, 2001.

8. The system shown in Exhibit B was built, assembled, and tested for its intended purpose in Building 1299, Room 138 located at the NASA Langley Research Center in Hampton, Virginia, before September 28, 2001. This same system shown in Exhibit B also worked for its intended purpose of alerting when a person or object is left unattended before September 28, 2001.

9. Before the system shown in Exhibit B was built, assembled, and tested, a first generation prototype of the invention defined by claims 1-46 of the above-identified patent application was also built, assembled, and tested before September 28, 2001, as evidenced by the Disclosure of Invention of Exhibit A, which indicates that a prototype was developed in Sections 12, 14, and 17(d). (See sections entitled "State of Development," "Indicate the Dates or the Approximate Time Period During Which This Innovation Was Developed" and "Development History.") This same first prototype also worked for its intended purpose before September 28, 2001, as evidenced by the Disclosure of Invention of Exhibit A, which indicates the first successful operational test was completed in Building 1299, Room 138 of the NASA Langley Research Center in Section 17 (e) under "Development History."

10. Exhibits A and B establish reduction to practice of the invention defined by claims 1-46 of the above-identified patent application in the United States of America before September 28, 2001.

Further deponents sayeth not.

William Christopher Edwards

Terry L. Mack

Edward A. Modlin

STATE OF VIRGINIA
CITY OF HAMPTON, to wit:

Sworn to and subscribed before me in the aforesaid City and State by William Christopher Edwards this _____ day of December, 2004

Elaine C. McMahon
Notary Public

My commission expires:

9-30-2007

STATE OF VIRGINIA
CITY OF HAMPTON, to wit:

Sworn to and subscribed before me in the aforesaid City and State by Terry L. Mack this 8th day of December, 2004

Elaine C McMahon
Notary Public

My commission expires:

9-30-2007

STATE OF VIRGINIA
CITY OF HAMPTON, to wit:

Sworn to and subscribed before me in the aforesaid City and State by Edward A. Modlin this 7th day of December, 2004

Elaine C. McMahon
Notary Public

My commission expires:

9-30-2007

EXHIBIT A

National Aeronautics and Space Administration

Disclosure of Invention and New Technology (Including Software)

Form Approved O.M.B. NO. 2700-0009	DATE
CONTRACTOR CASE NO.	
NASA CASE NO. (OFFICIAL USE ONLY) LAR 16324-1	

This is an important legal document. Carefully complete and forward to the Patent Representative (NASA in-house innovation) or New Technology Representative (contractor/grantee innovation) at NASA. Use of this report form by contractor/grantee is optional, however, an alternative format must at a minimum contain the information required herein. NASA in-house disclosures should be read, understood and signed by a technically competent witness in the witness signature block at the end of this form.

In completing each section, use whatever detail deemed appropriate for a "full and complete disclosure." Contractors/Grantees please refer to the New Technology or Patent Rights - Retention by the Contractor clauses. When necessary, attach additional documentation to provide a full, detailed description.

1. DESCRIPTIVE TITLE

Proximity Sensor

2. INNOVATOR(S) *(For each innovator provide: Name, Title, Phone Number, E-Mail Address, Home Address. For non U.S. citizen, include INS Form I-551 No. and expiration date. If multiple innovators, number each to match Box 5.)*

#1 William C. Edwards, Aerospace Technologest
757 864-1555, w.c.edwards@larc.nasa.gov
P.O. Box 947, White Marsh Va. 23183

#2 Terry Mack, Instrument Mechanic V
(757) 827-9098, t.l.mack@larc.nasa.gov
40 Peterborough Drive, Hampton, Va 23666

#3 Edward Modlin 757 864-1555
e.a.modlin@larc.nasa.gov
305 Treis Tr., Yorktown, Va.

3. INNOVATOR'S EMPLOYER WHEN INNOVATION MADE *(For each innovator provide: Name, Division and Address of Employer, Organizational Code/Mail Code, and Contract/Grant Number, if applicable. If multiple innovators, number each to match Box 5.)*

#1, 3 NASA Langley Research Center
Systems Engineer Compency
Org. Code: RFK, Hampton, Va 23681

#2 Lockheed Martin, Contract ID: SAMZ, WBS SAM03RD0
Airborne Systems Compency, Org. Code: RD
1237T1 South Marvin St, Mail Stop 371, Hampton Va 23681

NASA 00135

4. PLACE OF PERFORMANCE *(Address(es) where innovation made)*

Langley Research Center,
5 North Dryden Street (B1202) and 8 North Dryden Street (B1299)

5. EMPLOYER STATUS *(choose one for each innovator)*

GE — Innovator #1	GE — Innovator #3
LE — Innovator #2	____ — Innovator #4

GE = Government
CU = College or University
NP = Non-Profit Organization
SB = Small Business Firm
LE = Large Entity

6. ORIGIN *(check all that apply and provide all applicable numbers. If multiple Contracts/Grants, etc., list Contract/Grant Numbers in Box 3 with applicable employer information.)*

- ☐ NASA In-house Org. Mail Code _____
- ☐ Grant/Cooperative Agreement No. _____ UPN _____
- ☒ Prime Contract No. _____ UPN _____
  Task No. _____ Report No. _____
- ☐ Subcontractor; Subcontract Tier _____ UPN _____
- ☒ Joint Effort *(contractor, subcontractor and/or grantee contribution(s), and NASA in-house contribution)*
- ☐ Multiple Effort *(multiple contractor, subcontractor and/or grantee contributions, no NASA in-house contribution)*
- ☐ Other *(e.g., Space Act Agreement, MOA)* No. _____

7. NASA CONTRACTING OFFICER'S TECHNICAL REPRESENTATIVE *(COTR)*

8. CONTRACTOR/GRANTEE NEW TECHNOLOGY REPRESENTATIVE *(POC)*

9. BRIEF ABSTRACT *(A general description of the innovation which describes its capabilities, but does not reveal details that would enable duplication or imitation of the innovation.)*

See Attachment

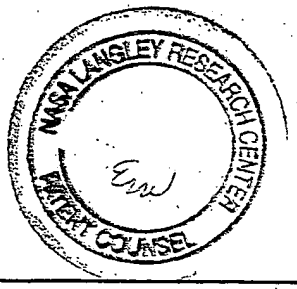
NASA LANGLEY RESEARCH CENTER PATENT COUNSEL

SECTION I - DESCRIPTION OF THE PROBLEM OR OBJECTIVE THAT MOTIVATED THE INNOVATION'S DEVELOPMENT *(Enter as appropriate: A.- General description of problem/objective; B.- Key or unique problem characteristics; C.- Prior art, i.e., prior techniques, methods, materials, or devices performing function of the innovation, or previous means for performing function of software; and D.- Disadvantages or limitations of prior art.)*

See Attachment

SECTION II - TECHNICALLY COMPLETE AND EASILY UNDERSTANDABLE DESCRIPTION OF INNOVATION DEVELOPED TO SOLVE THE PROBLEM OR MEET THE OBJECTIVE *(Enter as appropriate; existing reports, if available, may form a part of the disclosure, and reference thereto can be made to complete this description: A.- Purpose and description of innovation/software; B.- Identification of component parts or steps, and explanation of mode of operation of innovation/software preferably referring to drawings, sketches, photographs, graphs, flow charts, and/or parts or ingredient lists illustrating the components; C.- Functional operation; D.- Alternate embodiments of the innovation/software; E.- Supportive theory; F.- Engineering specifications; G.- Peripheral equipment; and H.- Maintenance, reliability, safety factors.)*

See Attachment

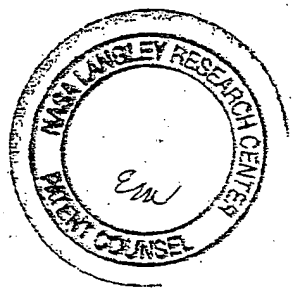


SECTION III - UNIQUE OR NOVEL FEATURES OF THE INNOVATION AND THE RESULTS OR BENEFITS OF ITS APPLICATION *(Enter as appropriate: A.- Novel or unique features; B.- Advantages of innovation/software; C.- Development or new conceptual problems; D.- Test data and source of error; E.- Analysis of capabilities; and F.- For software, any re-use or re-engineering of existing code, use of shareware, or use of code owned by a non-federal entity.)*

See Attachment

SECTION IV - SPECULATION REGARDING POTENTIAL COMMERCIAL APPLICATIONS AND POINTS OF CONTACT *(including names of companies producing or using similar products)*

See Attachment



10. ADDITIONAL DOCUMENTATION *(Include copies or list below any pertinent documentation which aids in the understanding or application of the innovation (e.g., articles, contractor reports, engineering specs, assembly/manufacturing drawings, parts or ingredients list, operating manuals, test data, assembly/manufacturing procedures, etc.).)*

TITLE	PAGE	DATE

11. DEGREE OF TECHNOLOGICAL SIGNIFICANCE *(Which best expresses the degree of technological significance of this innovation?)*

☐ Modification to Existing Technology ☒ Substantial Advancement in the Art ☐ Major Breakthrough

12. STATE OF DEVELOPMENT

☐ Concept Only ☐ Design ☒ Prototype ☐ Modification ☐ Production Model ☐ Used in Current Work

13. PATENT STATUS *(Prior patent on/or related to this innovation)*

☐ Application Filed Application No. _____ Application Date _____

☐ Patent Issued Patent No. _____ Issue Date _____

14. INDICATE THE DATES OR THE APPROXIMATE TIME PERIOD DURING WHICH THIS INNOVATION WAS DEVELOPED *(i.e., conceived, constructed, tested, etc.)*

Conceived _____ Constructed: _____ through _____ Testing _____ through _____

15. PREVIOUS OR CONTEMPLATED PUBLICATION OR PUBLIC DISCLOSURE INCLUDING DATES *(Provide as applicable: A.- Type of publication or disclosure, e.g., report, conference or seminar, oral presentation; B.- Disclosure by NASA or Contractor/Grantee; and C.- Title, volume no., page no. and date of publication.)*

16. QUESTIONS FOR SOFTWARE ONLY

(a) Using non-NASA employees to beta-test the program? ☒ YES ☐ NO If Yes, done under a beta-test agreement? ☐ YES ☒ NO

(b) Modification of this program continued by civil servant and/or contractual agreement? ☐ YES ☒ NO

(c) Copyright registered? ☐ YES ☒ NO ☐ UNKNOWN If Yes, then by whom? _____

(d) Has the latest version been distributed outside of NASA or contractor? ☐ YES ☒ NO ☐ UNKNOWN
If Yes, date of first disclosure: _____

(e) Were prior versions distributed outside of NASA or contractor? ☐ YES ☒ NO If Yes, supply NASA or contractor contact: _____

(f) Contains or based on code not owned by U.S. Government or its contractors? ☐ YES ☒ NO ☐ UNKNOWN
If Yes, name of code and code's owner: _____
Has a license for use been obtained? ☐ YES ☐ NO ☐ UNKNOWN

17. DEVELOPMENT HISTORY

STAGE OF DEVELOPMENT	DATE (MM/YYYY)	LOCATION	IDENTIFY SUPPORTING WITNESS (NASA In-House Only)
a. First disclosure to others		C & I proposal submission	C & I staff...Joe Hayman
b. First sketch, drawing, logic chart or code		B1299, Rm 138	Terry Mack
c. First written description		B1299, Rm 138	Terry Mack
d. Completion of first model of full size device *(invention)* or beta version *(software)*		B1299, Rm 138	Terry Mack, William Edwards
e. First successful operational test *(invention)* or alpha version *(software)*		B1299, Rm 138	Terry Mack, William Edwards

f. Contribution of innovators *(If jointly developed, provide the contribution of each innovator)*

T. Mack (Oper.,Design,Build,Testing) 80%,W. Edwards (Concept,Operation)15% ,E Modlin (Enclosure design & build)5%

g. Indicate any past, present, or contemplated government use of the innovation

18. SIGNATURES OF INNOVATOR(S), WITNESS(ES), AND NASA APPROVAL

TYPED NAME AND SIGNATURE *(Innovator #1)*	DATE	TYPED NAME AND SIGNATURE *(Innovator #2)*	DATE
WILLIAM C. EDWARDS William C. Edwards		TERRY L MACK Terry L Mack	
TYPED NAME AND SIGNATURE *(Innovator #3)*	DATE	TYPED NAME AND SIGNATURE *(Innovator #4)*	DATE
EDWARD A. MODLIN Edward A. Modlin			
YPED NAME AND SIGNATURE *(Witness #1)*	DATE	TYPED NAME AND SIGNATURE *(Witness #2)*	DATE

NASA ➤ APPROVED		SIGNATURE	

9. BRIEF ABSTRACT

The innovation is based around the need to prevent a child from being left in an unattended parked vehicle. Its capabilities are given below.

- The device is composed of a radio frequency transmitter, the child sensor module, and receiver, the driver alarm module. The child sensor module detects the presence of a child sitting a child safety seat and sends this information to the driver alert module. The child sensor module is located on the child safety seat. The driver alert module has an audible alarm and is attached on the key ring of the vehicle.
- The device is capable of alerting the driver (using sound) if a child has been accidentally left in a child safety seat in the vehicle and the driver is not in close proximity (10-20 feet) of the vehicle.
- The device does not have to be turned "on" and "off" by the user and uses standard 1.5 volt "AA" and "AAA" batteries. It remains "on" all of the time and arms itself when a child is placed in the child safety seat and the vehicle key ring is in proximity of the vehicle. It disarms when the child is removed from the safety seat and the vehicle key ring is near the vehicle. The battery life of the driver alarm and child sensor module will be approximately two years. The child sensor module and driver alert module are also equipped with a low battery indicator to alert the user if the batteries need replacing.
- Once the alarm on the driver alert module is activated, the user cannot turn off the audible alarm until the child has been removed from the child safety seat.
- The driver alarm or child sensor modules are not tied to the car electronics or hardware in any way. This insures that it could be used in any new or used car, minivan or sport utility vehicle.
- The driver alert and child sensor modules will beep to alert the driver that the units are arming when the child is placed in the seat and will beep indicating that the units are disarming when the child is taken out of the child safety seat.
- Installation of the child sensor module does not alter the operation of the child safety seat in any way. The device can be used in both new and existing child safety seats.

Section I:

Children and pets have often died or been injured because of extreme heat generated inside of parked vehicles. General Motors (GM) has recently reported in hat a car can reach temperatures of 150 degrees F in 20 minutes. Similar studies reported in the Journal of the Louisiana State Medical Society [Volume 147(12) reported that temperatures could exceed 125 degrees F in 20 minutes. A person who is unable to remove himself from an enclosed vehicle is at risk for a life-threatening crisis if left alone in a sun-exposed car for even a relatively short period of time. Along with extreme heat, cold temperatures can also impose a problem. If the driver can be notified that there is a child still in the vehicle within a short period of time, (before the environmental conditions start affecting the health of the child), tragedies involving the death can be avoided. GM reported that between and , 120 children have lost their lives in such accidents. There are many factors that may cause infant related deaths in vehicles. Some of these may include:

1. Parents getting reduced sleep because of the feeding habits of infants.
2. Day care drop off schedules and routines can change. (Different parent may drop off child)
3. A parent may be preoccupied with the upcoming events of the day and forget to drop off the child at the daycare center.
4. Child may be asleep (unnoticeable to driver) for an extended period of time.
5. The car seat for infants is often turned around preventing the driver from seeing the child by using the rear mirror. The seat is always located in the back for safety reasons.
6. Increased distance between child and driver in minivans and sport utility vehicles.
7. Tinted windows of these vehicles don't allow driver or others to view child inside when the driver is exiting the vehicle.
8. Infant deaths may occur quickly because of the intense heat buildup in summer or extreme cold in winter months.
9. Infants and young children are strapped in vehicles and cannot physically remove themselves.
10. Today's vehicles are sealed very tight and others can't hear the infant cries outside of the vehicle.
11. Infants and small children have a very low tolerance to dehydration.

It is clear that there are many factors that can contribute to accidents. All of these factors must taken into consideration when designing a sensor that will alert the driver of a child which has been accidentally left in a vehicle.

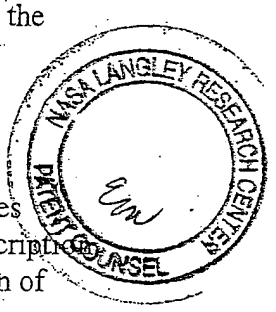
Advantages of Approach

There are several problems with existing technology for detecting children accidentally left in parted vehicle. Patents for similar technology reveal sensors that have several problems. Some of these problems range from having to wire the sensor to vehicle electronics to having them work in both new and existing cars and car safety seats. Many proposed sensors also rely on the vehicle horn to alert the driver that child has been left in a vehicle. A new sensor proposed by GM in ises this vehicle horn method to alert the driver or a pedestrian of a child left in an unattended vehicle. Many anti-theft devices also rely on the car horn and people often ignore horns that are activated in parking lots. Sensors that must be wired into a particular make of vehicle are complex, costly and difficult for the user to implement. A detail description of the previous attempts to develop a sensor and the associated problems can be found in the report "Inadvertent Child Abandonment: A Review of Existing Technologies and Barriers to Commercialization", Prepared By: Research Triangle Institute under NASA contract. NAS1-99134 dated Our new innovative approach solves the problems associated with existing technology and provides the following significant advantages.

1. **Inexpensive cost.** The unit parts cost is very low making the units economical to produce and sell.
2. **Small size.** The alert unit attaches to the vehicle key ring and can be easily put in a pocket or purse. The child sensor attaches to the side of the car safety seat using Velcro and does not interfere with the child car seat function in any way.
3. **Easily integrates into new and existing vehicles and child safety seats.** The sensors are not wired into the electrical or mechanical systems of the vehicle and can be easily

used in both new and used vehicles and car seats. Also, the sensors do not make existing car seat products and designs obsolete.

4. **No unproven technology used.** The microprocessor and radio communication technology used in the sensors is well established. They can be easily manufactured using commercially available components.
5. **Long battery lifetime.** The sensors use standard, low cost "AA" and "AAA" 1.5-volt batteries. The battery life has been calculated to be greater than two years under normal operating conditions. The modules have a low battery audible annunciation if the battery voltage is not adequate for operation. (2 beeps every half hour)
6. **The sensors require no user intervention to operate.** Once the batteries are placed in the sensors, the user does not need to cut the devices "on" or "off".
7. **Immediate sensor activation acknowledgement.** Both the driver alarm and child sensor modules "beep" when the child is placed in the safety seat to notify the user that the system has been armed and is functional.
8. **Audible alarm is located with the driver.** The design uses an audible alarm located on the key ring of the vehicle. This has the advantage of placing the alarm with the driver and does not rely on an alarm that is attached to the vehicle.
9. **Sensor modes of operation can be easily modified.** Since the sensors are controlled by a microprocessor using software, their modes of operation can be easily changed or modified. The alarm timing can be changed using software and the transmitting power can be easily adjusted by changing the value of a resistor. This flexibility allows the sensor to adapt to new needs as they are identified.



Section II: Design Approach

The Child Proximity Detector (CPD) is made up of two separate modules. These modules include a transmitter (child sensor module) and receiver (driver alarm module). The description of each sensor will be given including its operation and imbedded software. The function of each module is given below:

Child Sensor Module (Transmitter)

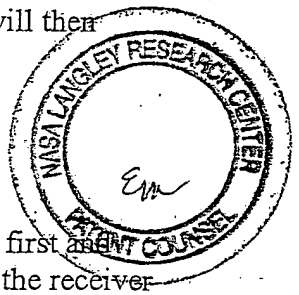
- Sensor activates using a mechanical contact "tape"switch when a child is placed in the child safety seat and deactivates when child is removed from safety seat. The switch has a large activation area and has a sensitivity of approximately 8 ounces.
- The user does not turn the sensor "on" or "off".
- Detects when child is in vehicle sending out a unique code to the driver alarm module using a radio frequency link.
- Unit will beep (2 times each 30 mins.) when the battery voltage low and the batteries need changing
- A "tape" switch is located in seat/back area of the child safety seat; the transmitter is fastened to the side of the car seat using Velcro.
- Audible annunciation upon placing the child in the car seat (1 beep)

Driver Alarm Module (Receiver)

- Module activates when the unit receives a code from the child sensor indicating a child has been placed in the child safety seat. It must be in proximity of child sensor module for this to occur.
- The user does not turn the module "on" or "off".
- Detects when child is in the child safety seat in the vehicle
- Activates (arms) when switch in child seat is activated, Deactivates (disarms) when child is removed from safety seat.
- Unit will beep (2 times each 30 mins.) when the battery voltage low and the batteries need changing
- Receives information from child sensor indicating the presence or not of a child in the vehicle.
- Unit hangs on vehicle key ring. This insures that it is always with the driver.
- Audible annunciation upon placing the child in the car seat (2 beeps, low to high tone) and sounds 2 beeps, high to low tone when the child is removed.

The overall theory as to how the child proximity detector works is as follows. The complete system is based on a wireless medium (RF at 916.50 MHz) and a miniature low power microcontroller in both the transmitter (child seat located in the vehicle) and the receiver located on the drivers key chain. The complete system runs off of ordinary batteries that can be purchased at most stores. It is designed for long battery life (approximately 2 years) and because it is a life saving device many features are built in designed to prevent an accidental mode that would allow the system to not perform its job.

The overall system consists of a transmitter (located on the infant car seat) and a receiver (located on the driver's key chain). The transmitter periodically wakes up every 2.3 seconds and polls the pressure switch used to sense the weight of the infant or child. This activates the transmitter, which causes the transmitter to send (over the RF medium) a 9600 Hz tone for a period of three seconds. This will be interpreted by the receiver as an Enable Code (EC) and thus arm the system. From this point on if the infant or child remains in the car seat, the transmitter will continue to wake up every 2.3 seconds, track time until 30 seconds has passed and then transmits over the RF medium a 4800 Hz tone for a period of 3 seconds. This is the Alive Code (AC) tone. This is received by the receiver to tell the overall system all is well. If for any reason the receiver should not receive the AC tone, and a period of one minute has passed the receiver will sound 10 warning tones and wait an additional minute allowing the receiver to be brought back into the vicinity of the transmitter. If it is not brought back into the vicinity of the transmitter the receiver will enter a permanent alarm state which can only be corrected by approaching the transmitter and removing the infant from the car seat. If the system is armed, and the infant or child is removed from the car seat, the transmitter will send a 2400 Hz tone. This will be interpreted by the receiver as a Disable Code (DC) tone. The receiver will then sound two audible alarms to notify the holder of the receiver all is well.



Operational Features include:

1) Audible annunciation upon placing the infant or child in the car seat (transmitter first and then the key chain receiver), 1 beep for transmitter and 2 beeps (low to high) for the receiver unit.

2) A very short audible annunciation every 5 minutes when the system is armed to remind the driver that the system is working and as a reminder that an infant or child is in the car seat.

3) Low battery audible annunciation in the transmitter and receiver, 2 low beeps every half hour.

4) If the infant should be left in the vehicle and the holder of the key chain receiver should leave the vicinity of the vehicle, the key chain receiver will sound 10 consecutive beeps within one minute. Thereafter the receiver key chain will wait an additional one-minute at which time it will beep continually until the key chain receiver is brought into the vicinity of the vehicle and the infant is removed from the car seat.

5) Audible annunciation upon removing the infant in the car seat (high to low).

Safety Design Features Include:

1) The car seat switch is permanently attached to the transmitter to prevent accidental removal of the pressure switch from the transmitter unit. If a connectorized system were used, the following scenario could take place. If the pressure switch were accidentally removed (fidgety child, other sibling, etc...) from the transmitter, the system would sound two beeps. Due to this situation the holder of the key chain receiver could (due to the radio, talking, daydreaming, etc...) inadvertently not realize that the key chain receiver has sounded signifying that the system thinks that the child has been removed from the car seat.

2) If the infant is placed into the car seat without the receiver key chain in the vicinity of the transmitter (car seat), the system is designed to arm once the key chain receiver is brought into the vicinity of the vehicle.

Battery Longevity Analysis

A battery analysis was done to determine the expected battery life. It was assumed in the calculations that the transmitter and receiver would be active 24 hours a day, 365 days a year. While the receiver will stay "on" continuously, the transmitter will only activate (use the battery) when a child is placed in the car safety seat. The charts below show the components that have the greatest battery use and the associated battery life in years.

In the transmitter module, the microprocessor (DR4000) yields a battery lifetime of >1.5 years. Since this device only activates when a child is placed in the safety seat, the expected lifetime will be much greater than this amount. (note: the child is never in the safety seat 24 hours a day) Unlike the transmitter, the receiver stays active all of the time and has continuous battery use. Again the microprocessor (DR5000) has the greatest battery use and limits the battery lifetime to >2.3 years. It should be remembered that each of the modules contains a low battery alarm that will alert the user if the battery voltage is to low.

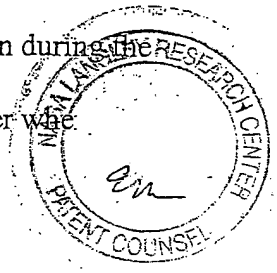
Child sensor module (Transmitter)

Company	Component	AA Battery = 2100mAH	Purpose	Current Drain
Linear Technology	LTC1502-3.3	4.8 years	Note 1	Continuous 50uA Hour
Maxim	MAX971CSA	48 years	Note 2	Continuous 5uA Hour
Microchip	PIC16C505-04/SL	>34 years	Note 3	Pulsed 1mA 3 secs every 30 secs
RFM	DR4000	>2.89 years	Note 3	Pulsed 12mA 3 secs every 30 secs

Driver alarm module (Receiver)

Company	Component	1 AAA Batteries = 1000mAH	Purpose	Current Drain
Linear Technology	LTC1502-3.3	2.3 years	Note 1	Continuous 50uA Hour
Maxim	MAX971CSA	23 years	Note 2	Continuous 5uA Hour
Microchip	PIC12C508-04/SM	52 years	Note 4	Pulsed 1mA 5 msec every 2.3secs
RFM	DR5000	29 years	Note 4	Pulsed 1.8mA 5 msec every 2.3secs

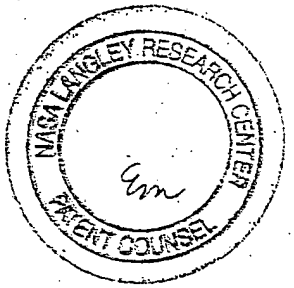
Note 1: Converts 1.5 Volts from battery to a fixed 3.3 Volts to run main circuitry.
Note 2: Monitors 1.5 Volts from battery and provides digital level shift if battery falls below 1.182 Volts.
Note 3: Based on one hour of use each day. The microcontroller/transmitter is only on during the time an infant is in the car seat.
Note 4: Battery longevity will be shortened due to current consumption of the sounder when in use.

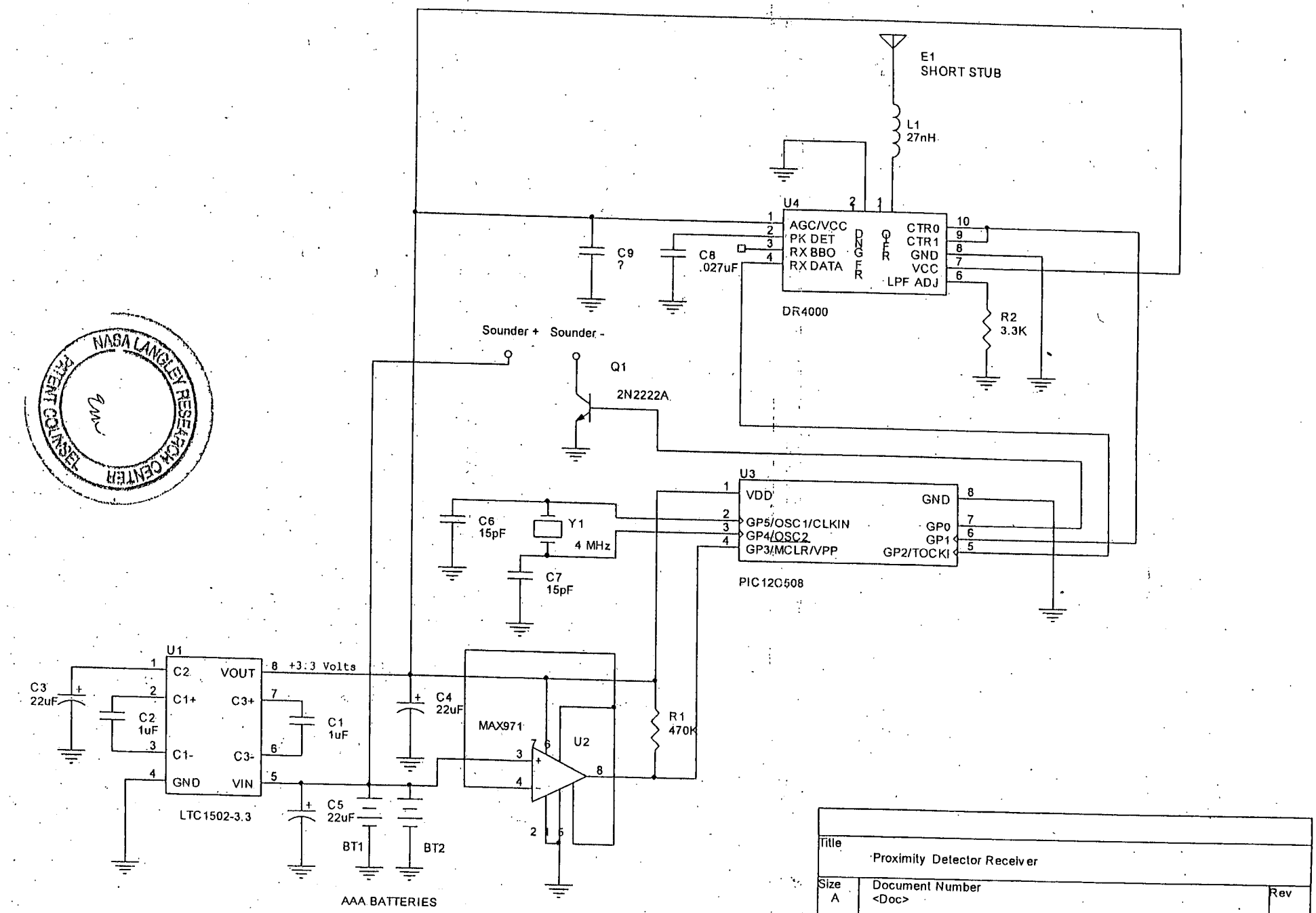


Proximity Detector Components Parts List

Item	Qty	Description	Vendor / Parts	Pkg.	Designation
		Resistors			
1	2	470K Ω 1/10W 5% SM for Transmitter	Digi-Key P470KACT-ND	0805	R1, R2
2	1	470K Ω 1/10W 5% SM for Receiver	Digi-Key P470KACT-ND	0805	R1
3	1	3.3K Ω 1/10W 5% SM for Receiver	Digi-Key P3.3KACT-ND	0805	R2
		Capacitors			
4	2	1 µF 16V Ceramic XR7 SM for Transmitter	Digi-Key PCC1882CT-ND	1206	C1, C2
5	2	1 µF 16V Ceramic XR7 SM for Receiver	Digi-Key PCC1882CT-ND	1206	C1, C2
6	3	22 µF 6.3V Spec Polymer SM for Transmitter	Digi-Key PCE3158CT-ND	D	C3 – C5
7	3	22 µF 6.3V Spec Polymer SM for Receiver	Digi-Key PCE3158CT-ND	D	C3 – C5
8	2	15 pF 50V Ceramic NPO SM for Transmitter	Digi-Key PCC150CNCT-ND	0805	C6, C7
9	2	15 pF 50V Ceramic NPO SM for Receiver	Digi-Key PCC150CNCT-ND	0805	C6, C7
10	1	.027 µF Ceramic XR7 SM for Receiver*	Digi-Key PCC1833CT-ND	0805	C8
11	1	*		0805	C9
		Inductors			
12	1	27 nH 0.26 RDC Max Ω SM for Transmitter	Digi-Key PCD1165CT-ND	2012	L1
13	1	27 nH 0.26 RDC Max Ω SM for Receiver	Digi-Key PCD1165CT-ND	2012	L1
		Semiconductors			
14	1	2N2222 Switching Transistor for Transmitter	Digi-Key FMT2222ATR-ND	SOT-23	Q1
15	1	2N2222 Switching Transistor for Receiver	Digi-Key FMT2222ATR-ND	SOT-23	Q1
		Active ICs			

16	1	DC to DC Converter 3.3V for Transmitter	Digi-Key LTC1502CS8-3.3-ND	SO8	U1
17	1	DC to DC Converter 3.3V for Receiver	Digi-Key LTC1502CS8-3.3-ND	SO8	U1
18	1	Low Power Comparator for Transmitter	Max971CSA	SO8	U2
19	1	Low Power Comparator for Receiver	Max971CSA	SO8	U2
20	1	Microcontroller for Transmitter	Digi-Key PIC16C505-04/SL-ND	SOIC	U3
21	1	Microcontroller for Receiver	Digi-Key PIC12C508-04/SM-ND	SOIC	U3
22	1	916.50 MHz Transmitter Module	RF Monolithics	Module	U4
22	1	916.50 MHz Receiver Module	RF Monolithics	Module	U4
Crystal					
23	1	Crystal 4.000 MHz for Transmitter	Digi-Key 300-1010-ND	CYL	Y1
24	1	Crystal 4.000 MHz for Receiver	Digi-Key 300-1010-ND	CYL	Y1
Miscellaneous					
25	2	AA PC Battery Clip for Transmitter	Digi-Key 92K-ND	AA	BT1, BT2
26	2	AAA PC Battery Clip for Receiver	Digi-Key 82K-ND	AAA	BT1 – BT4
27	1	Sounder for Transmitter	IntervoxBRT1209P-01-50		A1
28	1	Sounder for Receiver	IntervoxBRT1209P-01-50		A1
29	1	Pressure Switch for Transmitter			S1
30	1	PCB Board for Transmitter			
31	1	PCB Board for Receiver			
32	1	Tape Switch (Control Flex Ribbon Switch)	Tapeswitch Company 121-BP		switch





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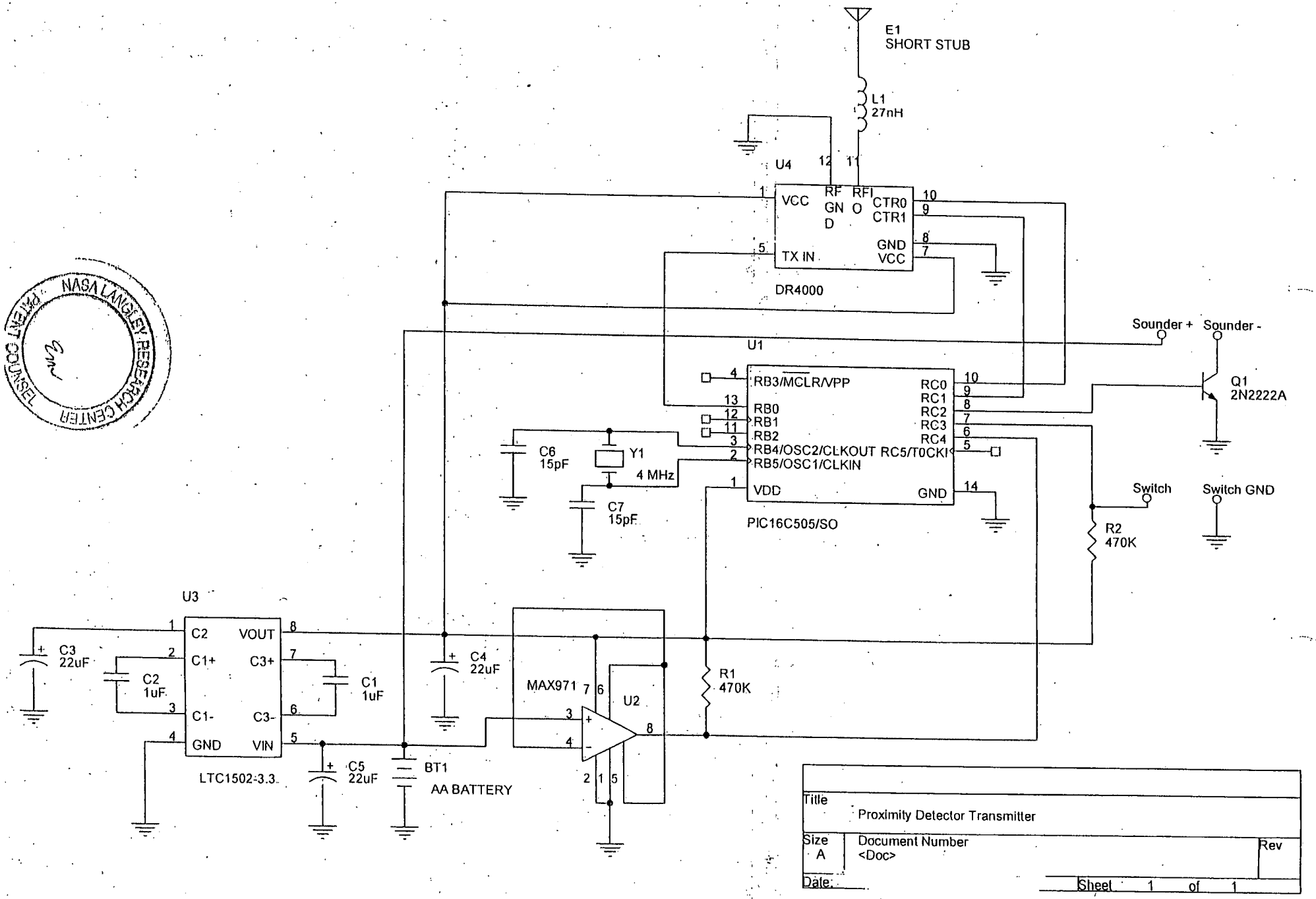


General User Operational Description

The user would place one "AA" battery in the transmitter (child sensor module). The child sensor module is mounted in any car seat that uses a hard plastic or metal frame covered with a fabric lined foam covering. This construction is common for infant and booster car seats. It is common for the fabric lined foam cover to be removable for cleaning purposes. While any type of contact switch can be used for detection of the child setting in the car seat, a tape switch was chosen. This switch is commercially available, gives a large activation area (0.5 x 12 inches), has a low activation force (8 oz) and easily bends to fit any car seat format. This switch is hard wired directly to the transmitter module. After the switch has been installed into the car seat using double back tape, the transmitter can be mounted to the side of the car seat using Velcro. The transmitter can be placed anywhere on the outside of the car seat. The child sensor module does not interfere with the operation of the car safety seat. The user would now place two "AAA" batteries on the receiver (driver alarm module) and fasten it to the key chain of the vehicle. The system is now ready for operation. When the child is placed into the car safety seat, the transmitter will beep once and the receiver will beep twice (low & high tone). This will alert the driver that the system is functioning properly and armed. If the transmitter or receiver beeps twice every half hour, the batteries need changing. Since the battery life is expected to be greater than two years, this will occur very infrequently. It should be noted that two receivers could operate using same transmitter. This would be the case where two sets of car keys were used with the same vehicle. Also, the user does not have to cut the transmitter or receiver "on" or "off". The operation of the system is automatic requiring no user intervention. If the user is more than 10-20 feet from the car safety seat, the system will produce ten tone burst to alert the driver that the child is still in the car seat. If the driver is still out of range more than one minute after the ten warning alerts, and receiver unit on the key chain will go into continues alarm until the child is taken out of the car seat. When the child is taken out of the child safety seat, the receiver will produce two (hi & low tone) beeps to alert the driver that the system has disarmed.

Software Code Including Technical Operational Description

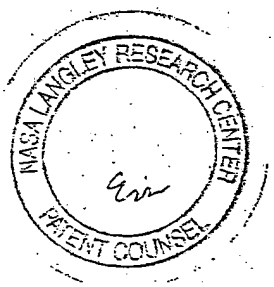
Proximity Detector Transmitter Code

Transmitter.asm

```
;-------------------------------------------------------------------------
; This routine runs the Transmitter Microcontroller ™ located in the child
; car seat. It sound an audible tone upon placing the AA battery into the
; battery clip to notify the user the transmitter is under microcontroller
; control. After the battery is inserted the TM will periodically wake up every
; 2.3 seconds and read the pressure switch (activated by placing the child in
; the car seat). If an infant is not in the seat the TM will simply go back to
; sleep to conserve battery power. If an infant is realized in the seat the TM
; will transmit an enable code tone (9600Hz for three seconds) to allow the
; Receiver Microcontroller (RM) to realize that it needs to arm itself. The TM
; will continue to wake up every 2.3 seconds and after 30 seconds has passed
; the TM will transmit an alive code tone (4800 Hz for three seconds) to notify
; the RM that the overall system is within proximity of each other. This will
; continue until the infant is removed from the car seat at which time the TM
```

```
; will transmit a disable code tone (2400 Hz for three seconds) to tell the RM
; system to disable. In addition the AA battery will be monitored for a voltage
; greater than 1.182 volts. If this is not the case the microcontroller will sound
; a beep every half hour to notify the user it is time to replace the battery.
;-------------------------------------------------------------------------------
; The WDT configuration Bit will be enabled
; The WDT will be assigned to the prescaler (2.3) second intervals
; RB0 used to output Tone Data
; RC0 used to control RFM Transmitter power down mode CTR0
; RC1 used to control RFM Transmitter power down mode CTR1
; RC2 used to drive the sounder
; RC3 used to sense the pressure switch located in the car seat
; RC4 used to read the low battery indicator circuit
;=============== PICT9.ASM=======================================================

        list    p=16c505
        radix   hex
;-------------------------------------------------------------------------------
;       cpu equates (memory map)
tmr0    equ     01
status  equ     03
portb   equ     06
portc   equ     07
acount  equ     08              ;loop delay variable
bcount  equ     09              ;loop delay variable
onplse  equ     0A              ;on pulse duration
offplse equ     0B              ;off pulse duration
flags   equ     0C              ;status flags
oldstat equ     0D              ;used to store status upon reset
time    equ     0E              ;used to timeout 1 minute for alive code
timeinc equ     0F              ;used to timeout 1 minute for low battery
lowbat  equ     10              ;used to timeout 30 minute low battery condition
;-------------------------------------------------------------------------------
;       destination designator equates
;-------------------------------------------------------------------------------
c       equ     0               ;carry flag
z       equ     2               ;zero flag
w       equ     0               ;destination
f       equ     1               ;destination
to      equ     4               ;time out bit
;-------------------------------------------------------------------------------
;       ports b and c i/o equates
;-------------------------------------------------------------------------------
tone    equ     0               ;tone data output
ctr0    equ     0               ;transmitter mode control
ctr1    equ     1               ;transmitter mode control
snd     equ     2               ;sounder drive
ps      equ     3               ;read pressure switch
lbat    equ     4               ;read low battery circuit
;-------------------------------------------------------------------------------
;       flags equates
;-------------------------------------------------------------------------------
switch  equ     0               ;0 = no child in seat 1 = child in seat
```

```
thirty   equ     1              ;1 = 30 seconds has passed
;-------------------------------------------------------------------------------
         org     0              ;memory location to start program
;-------------------------------------------------------------------------------
;        START OF PROGRAM
;-------------------------------------------------------------------------------
         movf    status,w       ;save power up status before it changes
         movwf   oldstat        ;store power up status to variable
;-------------------------------------------------------------------------------
         clrf    tmr0           ;clear TMR0
         clrwdt                 ;clear WDT and prescaler
         movlw   b'11001111'    ;select new prescale value
         option                 ;TMR0 to WDT
         movlw   b'00000000'    ;RB0 output
         tris    portb          ;portb configuration
         clrf    portb          ;all portb lines low
         movlw   b'00011000'    ;RC0,1,2 Outputs RC3,4 Inputs
         tris    portc          ;portc configuration
         clrf    portc          ;all portc lines low
;-------------------------------------------------------------------------------
         btfss   oldstat,to     ;is this a power up or WDT?
         Goto    operate        ;it's a WDT so operate program
;-------------------------------------------------------------------------------
; only executed on a power up
;-------------------------------------------------------------------------------
         clrf    time           ;it's a power up so clear 30 second time register
         clrf    flags          ;it's a power up so clear flags
         clrf    timeinc        ;it's a power up so clear 1 minute battery register
         clrf    lowbat         ;it's a power up so clear the 30 minute register
         call    alarm          ;notify user battery has been inserted
         goto    shtdwn         ;shutdown the transmitter key chain
;-------------------------------------------------------------------------------
; check for low battery condition
;-------------------------------------------------------------------------------
operate  btfsc   portc,lbat     ;test for battery less than 1.182Volts?
         goto    check          ;no goto one minute check routine
;-------------------------------------------------------------------------------
         incf    timeinc,f      ;yes increment register timeinc
         movf    timeinc,w      ;load timeinc results into W
         xorlw   d'26'          ;26 times 2.3 = 60 seconds
         btfss   status,z       ;is the z flag set?
         Goto    check          ;no goto one minute check routine
;-------------------------------------------------------------------------------
         clrf    timeinc        ; yes clear the 1 minute low battery register
         incf    lowbat,f       ;60 seconds passed so increment lowbat register
         movf    lowbat,w       ;load time info into W
         xorlw   d'30'          ;30 times 1 = 30 minutes
         btfss   status,z       ;if they match the z flag will be set
         goto    check          ;no goto one minute check routine
;-------------------------------------------------------------------------------
         call    alarm          ;notify user battery is low
         clrf    timeinc        ;clear the 1 minute low battery register
         clrf    lowbat         ;clear the 30 minute low battery register
```



```
;-------------------------------------------------------------------------
; increment and check if 30 seconds has passed
;-------------------------------------------------------------------------
check   incf    time,f          ;increment register time
        movf    time,w          ;load time results into W
        xorlw   d'13'           ;13 times 2.3 = 30 seconds
        btfss   status,z        ;is the Z flag set?
        Goto    readsw          ;no process child seat switch
        clrf    time            ;yes clear time register
        bsf     flags,thirty    ;30 seconds have passed so set flag
;-------------------------------------------------------------------------
; read pressure switch and act accordingly
;-------------------------------------------------------------------------
readsw  btfsc   portc,ps        ;is child in car seat?
        Goto    shtdwn          ;no shut down
        goto    process         ;yes go process
;-------------------------------------------------------------------------
shtdwn  bcf     flags,thirty    ;clear 30 second flag
        btfsc   flags,switch    ;test pressure switch flag status 0 = disabled
        call    disab           ;transmit 3 second disable code
        sleep                   ;good night
;-------------------------------------------------------------------------
process btfss   flags,switch    ;test pressure switch flag status 1 = enabled
        call    enable          ;transmit 3 second enable code
        btfss   flags,thirty    ;have thirty seconds passed by?
        Sleep                   ;no good night all is well
        call    alive           ;yes transmit 3 second alive code
        sleep                   ;good night
;-------------------------------------------------------------------------
; enable transmits 3 second 9600 Hz tone to the receiver
;-------------------------------------------------------------------------
enable  call    alarm           ;child in seat sound alarm
        bsf     flags,switch    ;set child in seat flag
        bsf     portc,ctr0      ;rf transmitter to on state OOK
        movlw   d'240'          ;times through the loop to create 3 seconds
        movwf   acount
ena     movlw   d'120'          ;times through the loop to create 3 seconds
        movwf   bcount
ena1    clrwdt                  ;make sure WDT doesn't time out
        movlw   d'17'           ;on pulse timing (9600Hz)
        movwf   onplse
        movlw   d'17'           ;off pulse timing (9600Hz)
        movwf   offplse
        bsf     portb,tone      ;tone pulse on (52usec)
enaon   decfsz  onplse,f
        goto    enaon
        bcf     portb,tone      ;tone pulse off (52usec)
enaoff  decfsz  offplse,f
        goto    enaoff
        decfsz  bcount,f        ;3 second timeout variable
        goto    ena1
        decfsz  acount,f        ;3 second timeout variable
        goto    ena
```

```
        bcf     portc,ctr0      ;rf transmitter to sleep mode
        retlw   0
;-------------------------------------------------------------------------
; alive transmits 3 second alive code to receiver 4800 Hz for 3 seconds
;-------------------------------------------------------------------------
alive   bcf     flags,thirty    ;clear 30 second flag
        bsf     portc,ctr0      ;rf transmitter to on state OOK
        movlw   d'121'          ;times through the loop to create 3 seconds
        movwf   acount
cod     movlw   d'121'          ;times through the loop to create 3 seconds
        movwf   bcount
codep   clrwdt                  ;make sure WDT doesn't time out
        movlw   d'34'           ;on pulse timing (4800Hz)
        movwf   onplse
        movlw   d'34'           ;off pulse timing (4800Hz)
        movwf   offplse
        bsf     portb,tone      ;tone pulse on (104 usec)
codeon  decfsz  onplse,f
        goto    codeon
        bcf     portb,tone      ;tone pulse off (104 usec)
codeoff decfsz  offplse,f
        goto    codeoff
        decfsz  bcount,f
        goto    codep
        decfsz  acount,f        3 second timeout variable
        goto    cod
        bcf     portc,ctr0      ;rf transmitter to off state
        retlw   0
;-------------------------------------------------------------------------
; disab transmits 3 second 2400 Hz tone to disable the receiver
;-------------------------------------------------------------------------
disab   bcf     flags,switch    ;clear no child in set flag
        bsf     portc,ctr0      ;rf transmitter to on state OOK
        movlw   d'120'          ;times through the loop to create 3 seconds
        movwf   acount
dis     movlw   d'60'           ;times through the loop to create 3 seconds
        movwf   bcount
dis1    clrwdt                  ;make sure WDT doesn't time out
        movlw   d'69'           ;on pulse timing (2400Hz)
        movwf onplse
        movlw   d'69'           ;off pulse timing (2400Hz)
        movwf   offplse
        bsf     portb,tone      ;tone pulse on (208usec)
dison   decfsz  onplse,f
        goto    dison
        bcf     portb,tone      ;tone pulse off (208usec)
disoff  decfsz  offplse,f
        goto    disoff
        decfsz  bcount,f        ;3 second timeout variable
        goto    dis1
        decfsz  acount,f        ;3 second timeout variable
        goto    dis
        bcf     portc,ctr0      ;rf transmitter to sleep mode
        retlw   0
```

```
;-------------------------------------------------------------------------
; alarm for low battery, battery insertion, and child in seat
;-------------------------------------------------------------------------
alarm   movlw   d'200'          ;value for 100 msec of sound
        movwf   acount          ;put it in the variable register acount
repet   movlw   d'83'           ;value for 2000 Hz or 250 usec on/off
        movwf   onplse          ;put value in variable register onplse
        movwf   offplse         ;put value in variable register offplse
        bsf     portc,snd       ;turn the sounder bit on
onbit   decfsz  onplse,f        ;decrement the register by 1
        goto    onbit           ;not zero? Decrement again
        bcf     portc,snd       ;turn the sounder bit off
offbit  decfsz  offplse,f       ;decrement the register by 1
        goto    offbit          ;not zero? Decrement again
        decfsz  acount,f        ;decrement the register by 1
        goto    repet           ;not zero? Repeat the process
        retlw   0
;-------------------------------------------------------------------------
        end
;-------------------------------------------------------------------------
;at blast time, select:
;       memory unprotected
;       watchdog timer enabled
;       standard crystal (using 4 MHz osc)
;       power-up timer on
;=========================================================================
```

Proximity Detector Receiver Code

Receiver.asm

```
;-------------------------------------------------------------------------------
; This routine is for the key chain Receiver Microcontroller (RM). It
; periodically wakes up every 2.3 seconds for a period of 5 msec. Two task are
; completed every time the RM wakes up. 1) a timer variable is updated
; indicating 2.3 seconds has passed. 2) the RM looks for an Enable Code (EC)
; (9600 Hz for 3 seconds from the TM) or an Alive Code (AC) by polling the
; positive pulse width (EC = 9600 Hz = 52 usec, AC = 4800 Hz = 104 usec). When
; the EC is realized the RM will set a flag realizing it has been armed and
; immediately turn off the receiver to conserve battery power. In addition two
; audible tones (enable = low to high tone) will then be generated to indicate
; the system is working. If an Alive Code (AC) is realized before the EC the
; system will arm, but no audible tones will sound. As mentioned in step 1) above
; every time the RM WDT times out a timer variable is incremented every 2.3
; seconds. If the system is enabled the timer variable will increment by one and
; then it will be tested. If 26 passes have occurred (26 x 2.3 = 60 seconds) the
; unit will check for a valid AC flag and if found all is well. The AC flag is
; realized when the RM is in the vicinity of the Transmitter Microcontroller
; (TM). Remember that the RM wakes up every 2.3 seconds and looks for the AC from
; the TM, if found a flag will be set. Once the RM is enabled, and the RM and TM
; are separated by 10 or more feet, the RM will no longer receive the AC. After
; one minute the holder of the RM will get a pre-warning of 10 audible tones. If
; the holder of the RM walks back into the vicinity of the TM the RM will realize
; the AC and all will be well. If the holder of the RM does not return to the
; vicinity of the RM after the pre-warning beeps, and a second minute passes, the
; RM will enter a  permanent alarm state which can only be cleared by removing
; the battery or by approaching the vehicle containing the infant and removing the
; infant from the car seat. The system will additionally sound two audible tones
; (high to low) when the infant is removed from the car seat (normal or alarm
; state). In addition a special feature exist that beeps for a very short
; period (40 msec) every 5 minutes when the system is armed to remind the holder
; of the key chain that their infant is in the car seat. A low battery circuit
; exist that will sound a single audible alarm every half hour should the
; battery voltage drop below 1.182 volts.
;-------------------------------------------------------------------------------
; GP0 will drive the sounder/vibrator
; GP1 is the receiver mode control
; GP2/TOCKI is used to read the tones
; GP3 reads the low battery circuit
;-------------------------------------------------------------------------------
;
;=========PICT9.ASM=============================================================
=========       =
        list    p=12c508
        radix   hex
;-------------------------------------------------------------------------------
;       cpu equates (memory map)
tmr0    equ     01
status  equ     03
```

```
gpio    equ     06
oldstat equ     07              ;used to store status upon reset
flags   equ     08              ;0/1=disabled/enabled bit 0=EC, 1=AC, 2=DC
pass    equ     09              ;variable used for the 10 msec second timeout
pass1   equ     0A              ;variable used for the 3 second timeout
alrm    equ     0B              ;variable used for alarm timeouts
time    equ     0C              ;used to track 1 & 2 minute timeouts
remind  equ     0D              ;used to remind driver child is in car seat
adly    equ     0E              ;variable used for delay routines
bdly    equ     0F              ;variable used for delay routines
lowbat  equ     10              ;30 minute low battery timeout register
batinc  equ     11              ;used to timeout 1 minute for low battery
ecode   equ     12              ;enable code result register
acode   equ     13              ;alive code result register
dcode   equ     14              ;disable code result register
;-------------------------------------------------------------------------
;       destination designations
;-------------------------------------------------------------------------
c       equ     0               ;carry flag
z       equ     2               ;zero flag
w       equ     0               ;working register
f       equ     1               ;file register
to      equ     4               ;time out bit
;-------------------------------------------------------------------------
;       gpio designations
;-------------------------------------------------------------------------
snd     equ     0               ;gpio sounder control bit
rec     equ     1               ;receiver mode control bit
tone    equ     2               ;read tone pulse width
lbat    equ     3               ;read the low battery circuit
;-------------------------------------------------------------------------
;       flags designations
;-------------------------------------------------------------------------
ec      equ     0               ;enable code flag 1=enabled
ac      equ     1               ;alive code flag 1=enabled
dc      equ     2               ;disable code flag 1=enabled
one     equ     3               ;one minute flag
two     equ     4               ;two minute flag
;*************************************************************************
********
        org     0               ;start of program
;-------------------------------------------------------------------------
; initialize processor routine
;-------------------------------------------------------------------------
        movf    status,w        ;save status before it changes
        movwf   oldstat
        clrwdt                  ;clear wdt and prescaler
        movlw   b'11001111'     ;WDT = 2.3 seconds TMR0 = internal cycle
        option                  ;prescaler to WDT
        movlw   b'00001100'     ;configure I/O
        tris    gpio
        clrf    gpio            ;all gpio lines low
        btfss   oldstat,to      ;is this a power up or WDT
```

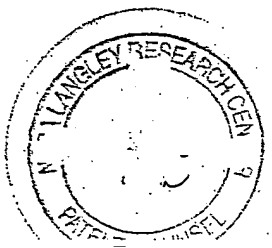
```
        goto    operate         ;WDT timeout so goto code routine
        call    alarm           ;notify user battery has been inserted
        clrf    time            ;power up so clear 1 & 2 minute timer
        clrf    flags           ;power up so clear all flags
        clrf    remind          ;power up so clear the 10 minute remind timer
        clrf    lowbat          ;power up so clear 30 minute battery timer
        clrf    batinc          ;power up so clear 1 minute battery timer
;*****************************************************************************
********
; This routine checks for a low battery condition and notifies the user with an
; audible tone every one half hour.
;-----------------------------------------------------------------------------
operatebtfsc    gpio,lbat       ;is the battery less than 1.182Volts?
        goto    fivemin                 ;no goto fivemin
;-----------------------------------------------------------------------------
        incf    batinc,f        ;yes increment register batinc
        movf    batinc,w        ;load time info into W
        xorlw   d'26'           ;26 times 2.3 = 60 seconds
        btfss   status,z        ;if they match the z flag will be set
        goto    fivemin         ;60 seconds not up so goto fivemin
;-----------------------------------------------------------------------------
        clrf    batinc          ;clear the 1 minute low battery register
        incf    lowbat,f        ;60 seconds passed so increment lowbat register
        movf    lowbat,w        ;load time info into W
        xorlw   d'30'           ;30 times 1 = 30 minutes
        btfss   status,z        ;if they match the z flag will be set
        goto    fivemin         ;30 minutes not up so goto fivemin
;-----------------------------------------------------------------------------
        call    alarm           ;notify user battery is low
        clrf    batinc          ;clear the 1 minute low battery register
        clrf    lowbat          ;clear the 30 minute low battery register
;*****************************************************************************
********
; This is the main routine. It tracks the WDT for time keeping purposes and
; works with the subroutine ecacdc to determine the system status based on
; tones from the Transmitter Microcontroller (TM)
;-----------------------------------------------------------------------------
; 5 minute overall system reminder routine only works if system is enabled
;-----------------------------------------------------------------------------
fivemin incf    remind,f        ;increment the remind register
        movf    remind,w        ;load remind check info into W
        xorlw   d'130'          ;130 times 2.3 = 300 seconds
        btfss   status,z        ;is the Z flag set?
        goto    minute          ;no goto minute
        btfss   flags,ec        ;is the unit enabled?
        goto    minute          ;no goto minute
        clrf    remind          ;yes clear the remind register
        call    salarm          ;call the short alarm routine
;-----------------------------------------------------------------------------
; call ecacdc to see if the transmitter is talking every 2.3 seconds for 5 msec
;-----------------------------------------------------------------------------
minute  call    ecacdc          ;is the transmitter talking?
```

```
;-------------------------------------------------------------------------
; clear ac flag if time register is equal to zero. This is to ensure that the
; one minute processing routine can properly enter the pre-warning mode.
;-------------------------------------------------------------------------
        movf    time,w          ;load time variable into w
        iorlw   d'0'            ;is the result = 0?
        btfsc   status,z        ;is the z flag clear?
        bcf     flags,ac        ;no clear ac flag status
;-------------------------------------------------------------------------
; time and flag routine determines if one or two minutes has passed by and sets
; the proper flags
;-------------------------------------------------------------------------
        incf    time,f          ;yes increment time check register
        movf    time,w          ;load time variable into W
        xorlw   d'26'           ;26 times 2.3 = 60 seconds
        btfss   status,z        ;is the Z flag set?
        goto    bypass          ;no goto bypass
        bsf     flags,one       ;yes set the one minute flag
bypass  xorlw   d'52'           ;52 times 2.3 = 120 seconds
        btfss   status,z        ;is the z flag set?
        goto    passby          ;no goto passby
        bsf     flags,two       ;set the two minute flag
        clrf    time            ;clear the time register
;-------------------------------------------------------------------------
; is the unit enabled processing routine
;-------------------------------------------------------------------------
passby  btfss   flags,ec        ;is the unit enabled?
        goto    done            ;no goto done
        goto    onemin          ;yes goto onemin
done    clrf    flags           ;unit not enabled so clear all flags
        sleep                   ;no good night all is well
;-------------------------------------------------------------------------
; one minute processing routine
;-------------------------------------------------------------------------
onemin  btfss   flags,one       ;has one minute passed by?
        goto    twomin          ;no goto twomin routine
        bcf     flags,one       ;yes clear the one minute flag
        btfss   flags,ac        ;is the alive code flag set?
        goto    prewarn         ;no goto the prewarn routine
        bcf     flags,ac        ;yes clear the ac flag
        sleep                   ;good night all is well
;-------------------------------------------------------------------------
; prewarn the holder of the key chain one minute has passed if they are out of
; the transmitter range
;-------------------------------------------------------------------------
prewarn movlw   d'10'           ;yes get ready for 10 warning alarms
        movwf   alrm            ;move to pass1 register
warn    call    alarm           ;warn via audible/vibrator
        call    pause           ;wait 100 msec
        decfsz  alrm,f          ;decrement pass1 register = 0
        goto    warn            ;not 0? do it again
        sleep                   ;good night all is well
```

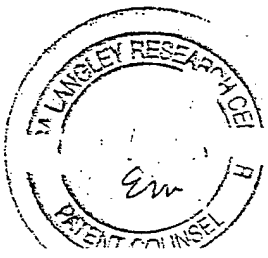
```
;-------------------------------------------------------------------------
; see if two minutes has passed
;-------------------------------------------------------------------------
twomin  btfss   flags,two       ;has two minutes passed by?
        sleep                   ;no goto sleep
        bcf     flags,two       ;yes clear the two flag
        btfss   flags,ac        ;is the ac flag set?
        goto    loop            ;no ac flag so alarm
        bcf     flags,ac        ;yes clear the ac flag
        sleep                   ;good night all is well
;-------------------------------------------------------------------------
; two minutes has passed and no AC was detected so alarm until infant removed
; from car seat or battery is removed
;-------------------------------------------------------------------------
loop    movlw   d'10'           ;yes get ready for 10 warning alarms
        movwf   alrm            ;move to pass1 register
warn1   call    alarm           ;warn via audible/vibrator
        call    pause           ;wait 100 msec
        decfsz  alrm,f          ;decrement pass1 register = 0
        goto    warn1           ;not 0? do it again
        call    pause           ;wait 100 msec to allow things to settle
        call    ecacdc          ;is the transmitter talking?
        btfss   flags,ec        ;has the unit been disabled?
        sleep                   ;yes go to sleep
        goto    loop            ;no repeat until child removed from car seat
;*************************************************************************
******
;SOUBROUTINES ARE LISTED FROM THIS POINT ON
;*************************************************************************
******

;-------------------------------------------------------------------------
; Subroutine ecacdc polls gpio 2 for up to 5 msec. When a code is found
; the receiver is shut down immediately to conserve battery power. In addition
; the proper flags will be set to determine system status. Pulse widths are as
; follows ec=52 usec, ac=104 usec, dc=208 usec
;-------------------------------------------------------------------------
;receiver turn in delay
;-------------------------------------------------------------------------
ecacdc  bsf     gpio,rec        ;enable the receiver
        movlw   d'65'           ;get ready to goof for 200 usec
        movwf   adly            ;to delay counter a
over    decfsz  adly,f          ;decrement counter a by 1
        goto    over            ;not zero do it again
;-------------------------------------------------------------------------
; clear timeout variables
;-------------------------------------------------------------------------
        clrf    adly            ;variable used for 200 usec timeout
        clrf    bdly            ;variable used for 5 msec timeout
;-------------------------------------------------------------------------
; make sure we are not on a positive pulse width
;-------------------------------------------------------------------------
```

```
lowp    btfsc   gpio,tone       ;see if the tone pulse width is low
        goto    lowp            ;no its high look again
;-------------------------------------------------------------------------
; poll the high pulse width or keep track of time
;-------------------------------------------------------------------------
hip     btfss   gpio,tone       ;see if the tone pulse width is high
        goto    timtrk          ;no goto time track
;-------------------------------------------------------------------------
        clrf    tmr0            ;yes determine pulse width
poll    btfsc   gpio,tone       ;poll pulse until it goes low
        goto    poll            ;not low yet? try again
;-------------------------------------------------------------------------
        movf    tmr0,w          ;store pulse width results
        movwf   ecode           ;move results to ec register
        movwf   acode           ;move results to ac register
        movwf   dcode           ;move results to dc register
;-------------------------------------------------------------------------
; see if its the disable code
;-------------------------------------------------------------------------
        movlw   d'188'          ;is this the disable code?
        subwf   dcode,f         ;lets find out
        btfss   status,c        ;is W < register result
        goto    alive           ;no go see if it is the alive code
        bcf     gpio,rec        ;disable the receiver
        clrf    flags           ;yes all flags disabled
        clrf    time            ;clear 1 & 2 minute timer
        clrf    remind          ;yes clear the remind register
        call    alarm           ;sound audible alarm/vibrator
        call    pause           ;wait 100 msec
        call    alarm           ;sound audible alarm/vibrator
        call    thresec         ;goof for 3 seconds so we don't repeat
        retlw   0               ;return from subroutine
;-------------------------------------------------------------------------
; see if its the alive code
;-------------------------------------------------------------------------
alive   movlw   d'84'           ;is this the alive code?
        subwf   acode,f         ;lets find out
        btfss   status,c        ;is W < register result
        goto    enable          ;no go see if it is the enable code
        bcf     gpio,rec        ;disable the receiver
        bsf     flags,ac        ;yes alive flag enabled
        bsf     flags,ec        yes enable flag enabled
        bcf     flags,one       ;yes one minute flag cleared
        bcf     flags,two       ;yes two minute flag cleared
        clrf    time            ;yes time register cleared
;       call    thresec         ;goof for three seconds so we don't repeat
        retlw   0               ;return from subroutine
;-------------------------------------------------------------------------
; see if its the enable code
;-------------------------------------------------------------------------
enable  btfss   flags,ec        ;has the unit already been enabled?
        goto    contin          ;no? then continue
        goto    hip             ;yes it was a false code so try again
```

```
;-------------------------------------------------------------------------------
contin  movlw   d'32'           ;is this the enable code?
        subwf   ecode,f         ;lets find out
        btfss   status,c        ;is W < register result
        goto    hip             ;no it was a false code so try again
        bcf     gpio,rec        ;disable the receiver
        bsf     flags,ec        ;enable flag enabled
        clrf    time            ;clear 1 & 2 minute timer
        clrf    remind          ;clear the remind register
        call    alarm           ;sound audible alarm/vibrator
        call    pause           ;wait 100 msec
        call    alarm           ;sound audible alarm/vibrator
        call    thresec         ;goof for 3 seconds so we don't repeat
        retlw   0               ;return from subroutine
;-------------------------------------------------------------------------------
; time track polls pulse width pin for either 5 msec
;-------------------------------------------------------------------------------
; 200 usec timeout routine
;-------------------------------------------------------------------------------
timtrk  incf    adly,f          ;increment 200 usec timeout register
        movf    adly,w          ;200 passes x 1 usec = 200 usec
        xorlw   d'22'           ;test for 22 passes x 9 instructions = 198 usec
        btfss   status,z        ;z flag set if they match
        goto    hip             ;not 200 usec so look again
        clrf    adly            ;200 usec so clear 200 usec timeout register
;-------------------------------------------------------------------------------
; 5 msec timeout routine
;-------------------------------------------------------------------------------
        incf    bdly,f          ;increment 10 msec timeout register
        movf    bdly,w          ;25 passes x 198 usec = 5 msec
        xorlw   d'23'           ;test for 23 passes x 14 instructions = 5 msec
        btfss   status,z        ;z flag set if they match
        goto    hip             ;not 10 msec so look again
        clrf    bdly            ;5 msec so clear 5 msec timeout register
        bcf     gpio,rec ;10 msec so turn off the receiver
        retlw   0               ;all done return from subroutine
;-------------------------------------------------------------------------------
; Subroutine alarm drives the piezo sounding device to indicate an audible tone
; to the holder of the key chain that an infant has been left in the car seat. The
; alarm condition beeps for 100 msec. In addition an optional motor vibrator may
; be added for the hearing impaired
;-------------------------------------------------------------------------------
alarm   clrwdt                  ;make sure device doesn't reset
        movlw   d'200'          ;value for 100 msec of sound
        movwf   pass            ;put it in the variable register pass
repet   movlw   d'83'           ;value for 2000 Hz or 250 usec on/off
        movwf   adly            ;put value in variable register adly
        movwf   bdly            ;put value in variable register bdly
        bsf     gpio,snd        ;turn the sounder bit on
onbit   decfsz  adly,f          ;decrement the register by 1
        goto    onbit           ;not zero? decrement again
        bcf     gpio,snd        ;turn the sounder bit off
offbit  decfsz  bdly,f          ;decrement the register by 1
```



```
        goto    offbit          ;not zero? decrement again
        decfsz  pass,f          ;decrement the register by 1
        goto    repet           ;not zero? repeat the process
        retlw   0
;-------------------------------------------------------------------------
; Subroutine salarm drives the piezo sounding device to indicate an audible tone
; to the holder of the key chain that the system is armed as a reminder that an
; infant is in the car seat. This routine is called every 10 minutes.
;-------------------------------------------------------------------------
salarm  movlw   d'40'           ;value for 20 msec of sound
        movwf   pass            ;put it in the variable register pass
repet1  movlw   d'83'           ;value for 2000 Hz or 250 usec on/off
        movwf   adly            ;put value in variable register adly
        movwf   bdly            ;put value in variable register bdly
        bsf     gpio,snd        ;turn the sounder bit on
onbit1  decfsz  adly,f          ;decrement the register by 1
        goto    onbit1          ;not zero? decrement again
        bcf     gpio,snd        ;turn the sounder bit off
ofbit   decfsz  bdly,f          ;decrement the register by 1
        goto    ofbit           ;not zero? decrement again
        decfsz  pass,f          ;decrement the register by 1
        goto    repet1          ;not zero? repeat the process
        retlw   0
;-------------------------------------------------------------------------
; Subroutine pause delays for 100 msec
;-------------------------------------------------------------------------
pause   movlw   d'130'
        movwf   adly
outer1  movlw   d'255'
        movwf   bdly
mid1    decfsz  bdly,f
        goto    mid1
        decfsz  adly,f
        goto    outer1
        retlw   0
;-------------------------------------------------------------------------
; Subroutine 3sec delays for 3 seconds
;-------------------------------------------------------------------------
thresec movlw   d'16'
        movwf   pass            ;to pass counter
        movlw   d'255'
        movwf   adly            ;to adly counter
skip    clrwdt                  ;make sure device doesn't reset
        movlw   d'255'          ;this number x 3=765
        movwf   bdly            ;to bdly counter
skip1   decfsz  bdly,f          ;decrement bdly register (1 clock)
        goto    skip1           ;not 0? do it over (2 clocks)
        decfsz  adly,f          ;decrement adly register
        goto    skip            ;not 0? lets retry 255 x 765 = 195,075
        decfsz  pass,f          ;decrement pass register
        goto    skip            ;not 0? lets retry 16 x 195,075 = 3.1 seconds
        retlw   0               ;done
;-------------------------------------------------------------------------
```



```
        end
;-------------------------------------------------------------------------
;at blast time, select:
;       memory unprotected
;       watchdog timer enabled
;       standard crystal (using 4 MHz osc)
;       power-up timer on
;=========================================================================
```

Section III

Unique or novel features of the innovation and the results or benefits from its application

1. **Child detection system is fully automatic.** The unit does not have to be turned "on" or "off" by the user. Benefit: Eliminates the possibility of the user forgetting to activate the system.
2. **Easily integrates into past, present or future vehicles.** The detector system does not directly interface with the vehicle by use of wiring or mechanical means. This provides a large degree of flexibility for its use.
3. **Easily integrates into past, present or future child safety seats.** Since the transmitter does not alter the function of the child safety seat (does not changes it's design in anyway), it can be easily integrated with nearly all child safety seats.
4. **No unproven technology used.** The microprocessor and radio communication technology used in the sensors is well established. They can be easily manufactured using commercially available components. The parts are inexpensive.
5. **Long battery lifetime.** The sensors use standard, low cost "AA" and "AAA" 1.5-volt batteries. The battery life has been calculated to be greater than two years under normal operating conditions.
6. **Audible alarm is located with the driver.** The design uses an audible alarm located on the key ring of the vehicle. This has the advantage of placing the alarm with the driver and does not rely on an alarm that is attached to the vehicle.

Exhibit B: NASA Case No. LAR 16324-2